A personal message from the Managing Director

In the pages that follow, the chief activities of this Company during the year 1960–61 are described under two main headings; electrical engineering, and electronics and automation.

Within these two broad fields lies the heart of the efforts of our 17,000 people in the United Kingdom, Canada, Australia and the United States although, as you will see, the Company engages in many allied activities for a wide variety of industries at home and overseas.

The Company is experienced in both the electrical and electronics industries. For nearly 80 years it has manufactured equipment for the transmission and recording of electrical power. Today some of the largest power transformers ever built in Europe and half the household electricity meters exported by this country come from our factories in Manchester.

In the young industry of electronics and automation 'experienced' is a relatively easy term to use. Over the last 10 years this industry, vital to the progress of the country, has become a major force in the economy, producing some £400,000,000 in goods and services annually, of which a quarter is exported.

It is difficult to grasp the speed of growth and rate of change in this new industry, but at its hub is the electronic computer. Ten years ago the world's first commercially available electronic computer left our plants. This year one of the most powerful computers in existence and 1,000 times faster than the original will be completed for a customer. It is something like moving from the horse to the aeroplane age in ten years.

Within the next few years great advances will be seen in the use and application of computers for control of machines, production processes, communications, data processing and scientific calculations. And there will be dramatic changes in the multitude of electronic components and instruments that make up these complex machines and systems.

It is the business of this Company to contribute original ideas and quality workmanship to this industry so that these complex machines and systems can be harnessed to the national effort in factories, offices, at sea and in the air – and space.

In this rapidly changing scientific age the magnitude of the research and development effort to keep abreast and ahead of changes throughout the world is considerable. For this we are utterly dependent on the creative ability of the human being which no machine, however wonderful, can possess. Without men and women of goodwill, scientists of imagination and technicians of skill, the essential effort necessary to progress cannot be sustained.

Sebastian de Ferranti.

Managing Director

Computers

The keynote of the past year's activities in the Computer Department has been expansion. This has been in two main directions. The first is an increase of manufacturing capacity at the West Gorton factory and the building of new laboratories at Bracknell. The second is the increased effort put into applications studies and service work, necessitating the opening of a second London Computer Centre at Newman Street, W.1, and a Northern Computing Service at Hollinwood.

At West Gorton two new buildings, giving an extra 31,480 sq. ft. of floor space, have been erected within the factory area. One is a wiring shop, which is at present concentrating on the assembly of components for the Orion computer system. Since the Orion was introduced in November, 1959, fourteen of these large time-sharing machines have been ordered, and this led directly to the reorganisation of production facilities. The second building is a large receiving, packaging and despatch centre in which completed computers can be loaded directly on to transport vehicles.

Within the original factory buildings, large-scale improvements are being made in the existing production lines to speed the manufacture of computers on mass-production principles.

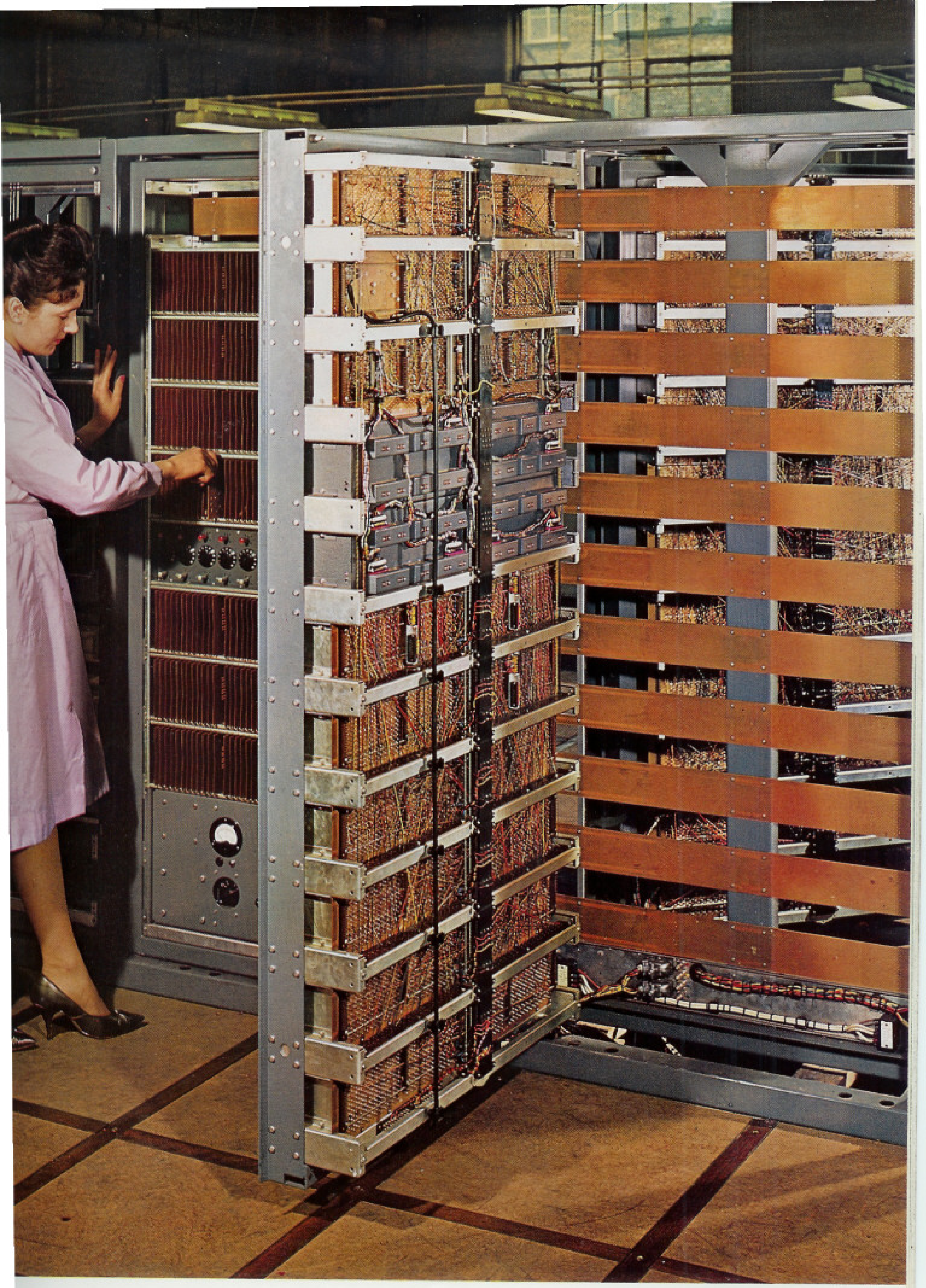
At Bracknell a new 58,000 sq. ft. building is being constructed in the factory area of the New Town. About two-thirds of this will be devoted to computer research and development, while the remainder will be used for research and development on aircraft equipment. The building is expected to be completed and occupied by the end of the year.

The new establishment at Newman Street gives an extra 28,000 sq. ft. of floor space. It functions as both a computer service centre and as a headquarters for the sales department. The activities of the sales department involve detailed studies of various fields of application, and in practice there has to be a good deal of collaboration between the people doing this work and the computing service staff. A Pegasus 2 data-processing equipment and a Sirius computer have already been installed in the computer demonstration room, and an Orion system is to be installed in 1962.

Many different fields of application are being studied, but those which will probably have the most direct effect on the general public are data-processing in insurance and banking. In both cases the basic requirement is for a large-capacity electronic reference system which will keep a record of all accounts or policies, which will take note of all transactions and amendments as they occur and which can be rapidly consulted for information as often as required. Customers for this type of system include such well-known names as the Prudential Assurance Company, the Norwich Union Insurance Company, the Westminster Bank, the National Provincial Bank and Martins Bank. Several large industrial companies have also ordered this computer, including Beecham Group Ltd. and The Metal Box Company.

These applications call for large-scale systems using the Orion or Pegasus 2 computers. There has been an increasing demand, however, for small computing systems based on the Sirius machine. More and more organisations are finding a need for limited computing facilities which can be provided at reasonably low cost, and orders for the Sirius, covering both technical and commercial applications, have now reached double figures.

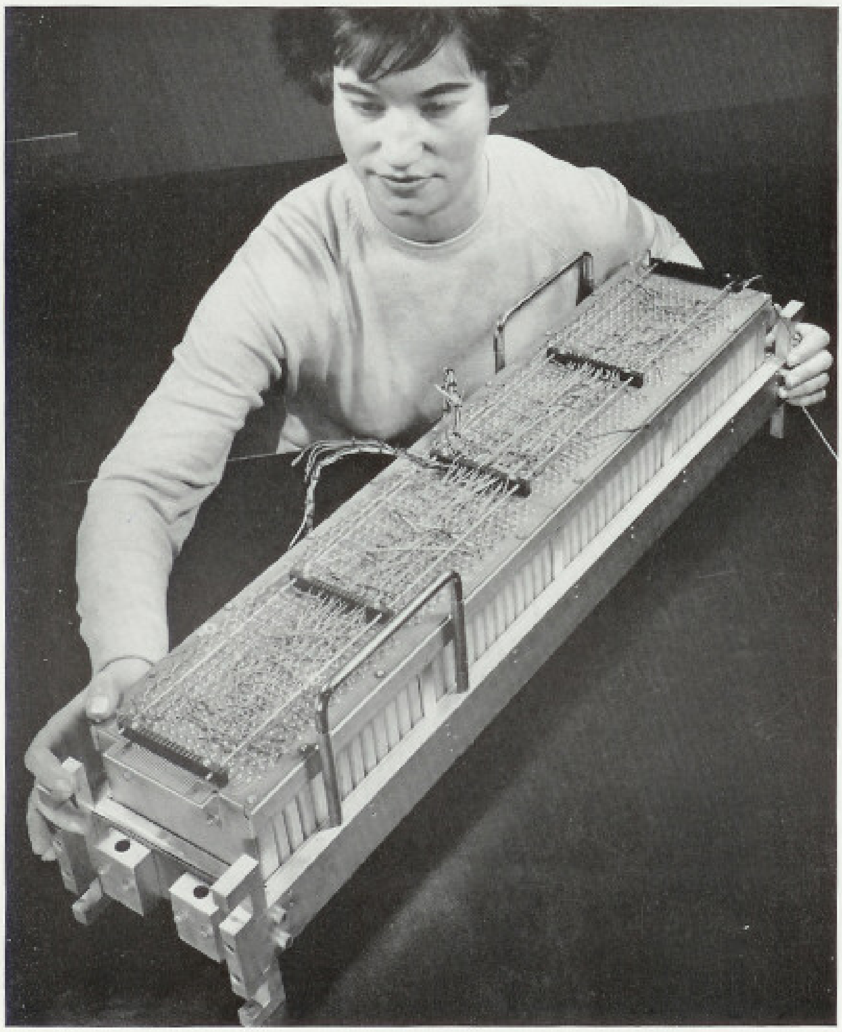
Another important field which the Computer Department has entered and which is likely to have a considerable effect on future industrial efficiency is the direct control of industrial processes by computers. During the year the construction of two Argus computer systems for this type of application has been undertaken. One has been ordered by Imperial Chemical Industries for the direct control of a chemical plant and the other by Babcock and Wilcox for the start up and shut down of a large boiler in a power station. Both are "firsts" in their respective fields.



small section of the Orion computer under construction.

TESTING COMPUTER BOXES

by C. Robinson, B.Sc., West Gorton Factory



1

A computer box, as used to build up the main section of Orion

AMONGST the various stages involved in the manufacture of an electronic computer, the part played by the Inspection Department is an extremely important one; this applies particularly to the inspection of the back-wiring. In order to understand what is involved, it is necessary to explain that the main section of a computer is built up of a number of units known as boxes.

A typical Orion box is illustrated in Fig. 1; this is built up of 48 connectors, each 32-way, to take printed circuit logical packages. The sockets are terminated at the rear of the box with pins; in the case of Orion and Atlas boxes, the total number of pins per box is 1536. On average, about half of these pins are interwired, that is wired to other pins of the same box, the remainder being wired to other boxes, or left spare.

It will be appreciated, therefore, that the process of checking that the box is wired correctly, and that all joints make good connections, is a lengthy operation requiring considerable care on the part of the inspector. A continuity test will check successfully that all wires indicated on the wiring schedule are present, but even the most conscientious inspector can overlook surplus wiring connections not included in the schedule, particularly where the wiring is crowded. Apart from wiring mistakes, these extra connections can be caused by short-circuits due to drops of solder, snips of wire, etc.

Most faults would eventually be discovered by the Commissioning Engineer when the box had been installed in the computer, but only after valuable time had been wasted, and possible damage to packages had occurred. Moreover, it is even possible for faults to become apparent after installation at the customer's premises, due to a combination of programming requirements not encountered at the commissioning stage. It is evident, therefore, that some means is essential for checking box wiring automatically.

Various methods have been considered; for example, one system involving comparing the box under test with a correctly-wired standard box was rejected, owing to the impracticability of keeping on hand boxes of every type used. For instance, approximately 150 types of box would be required when testing Orion units alone.

Point-to-point checking methods were dismissed, mainly because of the volume of wiring required in the test equipment, and also because of the number of testing operations required to check from each pin to every other pin.

In the system adopted, and at present in use in the Computer Test Department at West Gorton, a wiring pattern corresponding to that of the box under test is first set up by the test equipment. The wiring information relating to the box under test is then read into the test equipment from a five-hole paper tape reader, as shown in Fig. 2. The circuitry in the equipments acts on this information, to cause the wiring of one group of connections to be simulated, and the simulation is then compared with the actual wiring group under test. Any discrepancy between the simulated and actual condition, in the form of a missing or surplus wire, causes a "fault" indication to be given. Each complete wiring run is treated in this way, and the complete test schedule for the box constitutes a series of such individual tests.

The simulation of the wiring is achieved by means of dry reed relays. These relays are arranged in the form of a 48 × 32-way matrix, to correspond with the pins of a box. This means that there are 1536 relay circuits, each of which makes connection with a corresponding pin on the box under test.

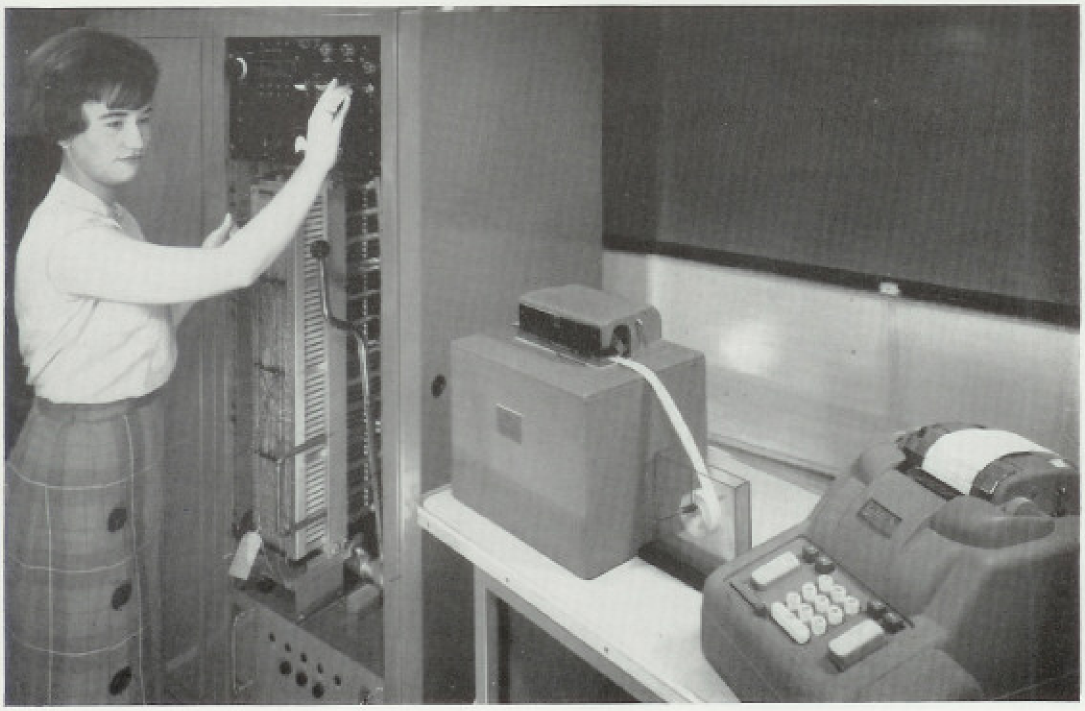
The test equipment is designed to work off a programme whose print out is itself a readable wiring schedule, and part of a typical print out is shown in Fig. 3. A pin number comprises four characters specifying the co-ordinates of the pin, for example, the fi

16,21 signify card position 16, connector pin 21. The first group in Fig. 3 supplies the information that the three pins indicated are wired together, and the second group that a single pin, 36,12, is not wired to any other pin, and is inserted into the programme to ensure that no such connection is in fact made. If it were made, such a wiring error would cause a non-equivalence condition, and a fault would be indicated.

The output signals from the tape reader are sampled by logical circuits. Information relating to the box type-number, and titles of wiring runs, is rejected, and characters concerned with pin numbers are decoded into a suitable form to cause the relays in the matrix to be selected and operated.

A storage circuit, consisting of four groups of flip-flops, remembers, or stores, the four characters of a pin number until the next pin number is read in to the equipment; the latter then stores this new number, rejecting the previous one. When the relays corresponding to a wiring run have been selected and operated, a test circuit is closed to make a comparison. If the simulated and actual connections do not agree, the tape reader is inhibited, and the last number to be read into the equipment, which is stored in the memory circuit, is converted from binary to decimal form and released to a strip printer, shown next to the tape reader in Fig. 2. After this number has been printed, the inhibition is automatically removed from the tape reader, and testing continues on the next group of wires.

The whole testing procedure is completely automatic, from the time that the operator feeds the tape into the reader and presses the "start" switch until the end of the test, and the equipment could if necessary be left unattended.



2 *Computer box in the equipment at West Gorton, ready for test by comparison with a simulated group of connections fed in from the tape reader on the right*

16,21
18,17
19,32

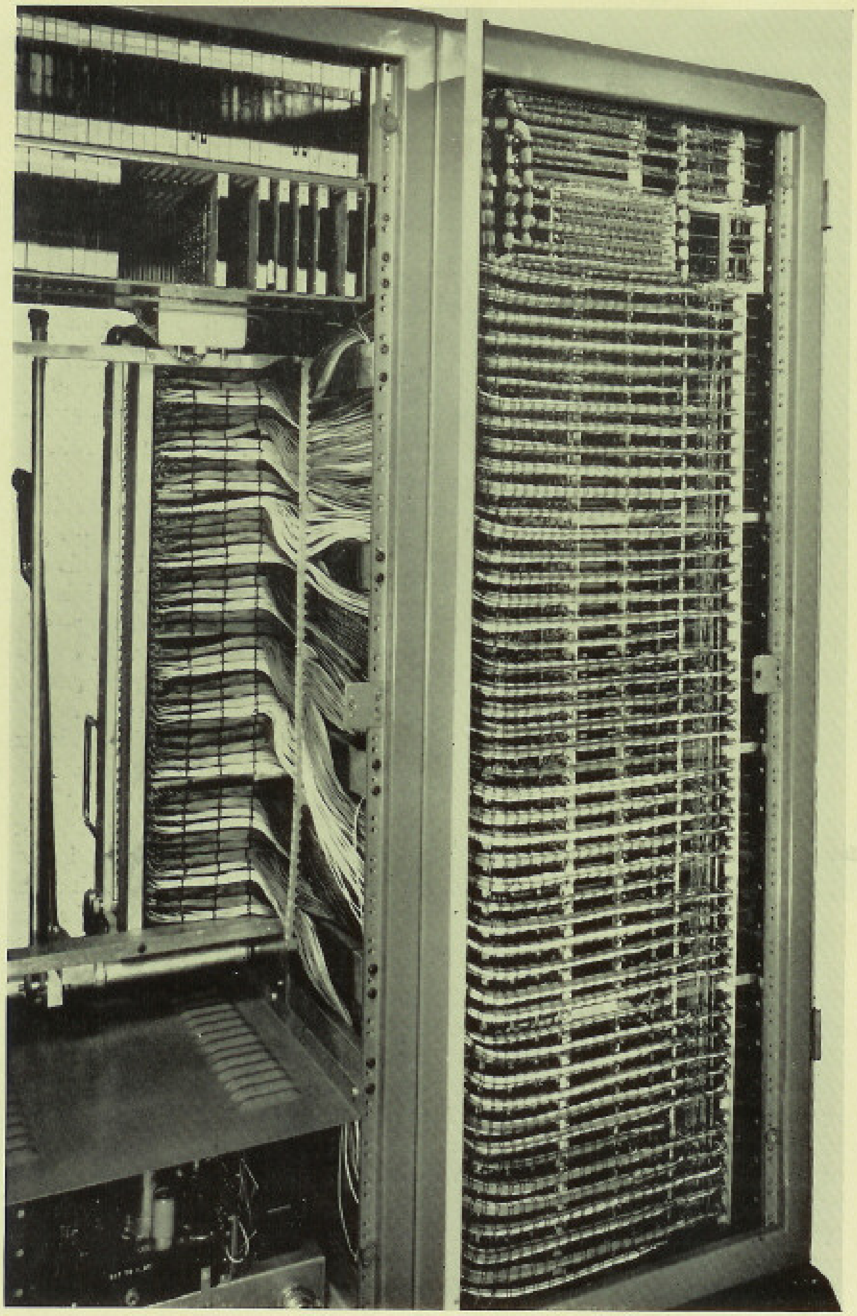
36,12

45,19
45,28

3 *Extract from the print out of a typical test programme*

The printed fault sheet is removed from the printer at the end of the test. Each number on it indicates the last pin number of a faulty group, and each faulty group on the box is examined to determine the nature of the fault. The box is then returned to have the wiring rectified. After rectification, the test routine is repeated, to ensure that repairs have been carried out satisfactorily.

The operating speed of the tape reader is approximately 40 characters per second, allowing 5–6 pins to be tested per second, and the time taken for the tape to run through the reader varies between two and five minutes, depending on the volume of wiring on the box and the number of faults present.



4
The back-wiring of the test equipment shown in Fig. 2. The plug carrying the computer box under test is of course on the left in this view

The equipment is also capable of testing for high-resistance joints, that is of verifying that the resistance of each joint does not exceed 0·1 ohm, a facility which can be brought into operation by means of a switch. The operating procedure is exactly the same as for checking that the wiring is correct, except that the test is done on the rectified box. The print out in this case specifies the precise locations of the high-resistance joints, as opposed to the faulty groups in the case of the check for wiring errors.

As shown in Fig. 2, the equipment is built into a two-bay cabinet (the back-wiring is shown in Fig. 4). The right-hand bay is mainly occupied by the plug into which the box is inserted. The plug is built up of a bank of 48 printed circuit extender boards. To insert an Atlas or Orion type box, the operator first fits a clamping jig round the box, and then inserts this assembly on to the plug. The insertion is achieved by pushing a long handle which, via a linkage mechanism, causes rollers to engage with jaws in the clamp. Completing the movement of the handle causes the rollers to push the clamp and the box fully home on to the extender boards.

Above the box fixture is a control panel, on which are mounted the switches, and a decimal display indicating the pin numbers being checked. These numbers are constantly changing, but a switching facility allows the testing routine to be operated manually step-by-step, if it is required to monitor the numbers of the pins being checked at any stage of the test. Other switching facilities allow the process to be changed from fully-automatic working to semi-automatic, or "stop-at-fault", working.

In the last-mentioned condition, the test equipment continues to run until a fault is encountered. The tape reader then stops, and the number in the decimal display indicates the location of the faulty wiring run. After investigation, the operator presses a "reset" switch. After printing the pin number, the equipment carries on working until the next fault appears.

Two boxes of Argus type NOR logic cards are mounted at the rear of the equipment, behind the control panel. The main function of the logic is to route the incoming characters relating to the pin numbering to flip-flop and diode decoding circuits, which in turn select and energize the appropriate relays.

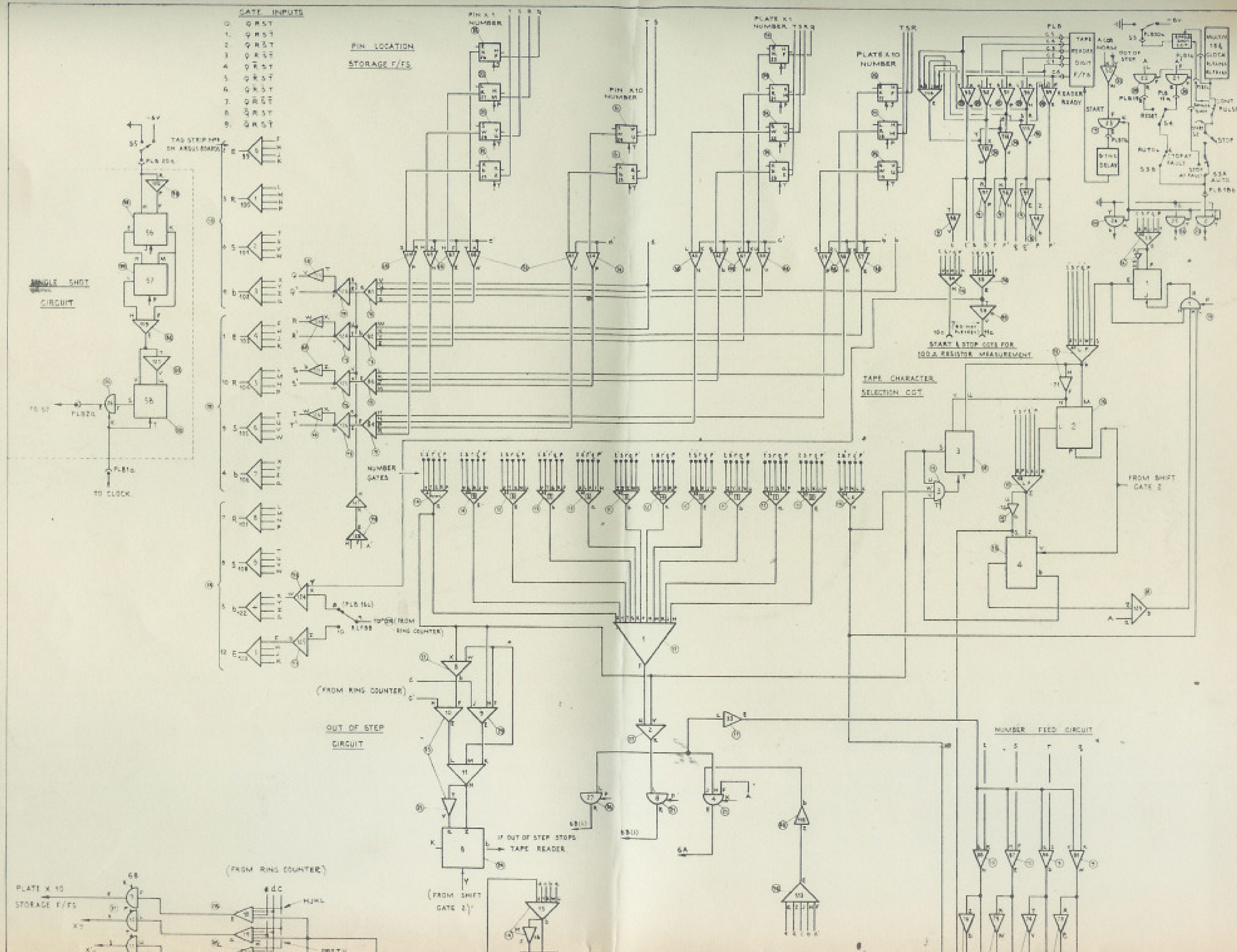
The relay matrix consists of 48 double-sided printed circuit boards, each measuring 19″ by 23″, as illustrated in Fig. 5. Because of the requirement to test the resistance of the joints in the box, and also because of the high reliability required, sealed contact relays are used, rather than transistors. These relays are in the form of glass capsules, each containing a pair of magnetically-operated contacts, sealed in an inert gas. The contact resistance is low (25–40 milliohms), and a life expectancy of over 100 million operations is claimed by the manufacturers.

As a matter of interest, just over 23,000 components, in the form of relay coils, contacts, diodes, and resistors are used altogether in the relay matrix, and the total number of soldered joints adds up to over 50,000. Fortunately, by the nature of the system, the equipment is capable of diagnosing its own faults, and this feature proved to be most useful while the equipment itself was being constructed and commissioned. To do this, a test programme was written which, when read into the equipment, enabled every relay to operate in sequence. A test box was prepared, by wiring pairs of pins together throughout the box to correspond with the programme. By inserting this box into the equipment, and running the test tape through the reader, any faults in the matrix or decoding circuits, such as non-operation of relays, faulty components, wiring errors, or dry joints, caused non-equivalence conditions to be set up, and faults to be printed. It was then a relatively easy matter to locate the boards responsible for the faults, and the circuits on the board which were faulty.

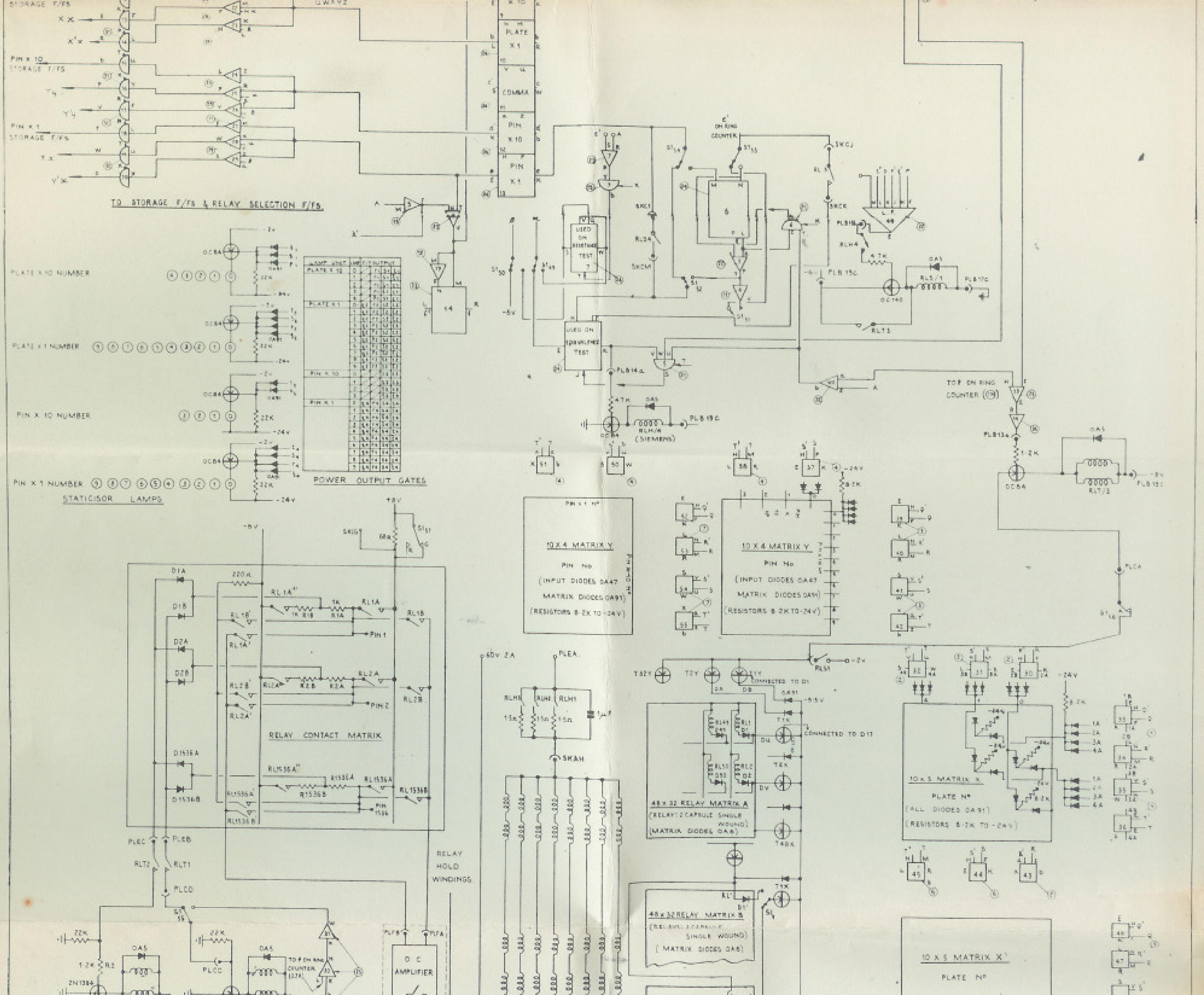
The test equipment has been designed to "fail safe"; that is to say, it is possible that a fault indication could be given due to an internal or a tape reader failure, although no actual fault existed on the corresponding wiring run on the box. On the other hand, it is almost impossible for any genuine box faults to remain undetected. A test equipment fault would be verified when the operator had examined the box after testing.

The equipment is adaptable for testing any wiring network or multi-way cableform, up to a maximum of 1536 ways. A possible application envisaged is the testing of different types of multi-way cableforms, assuming that these are produced in sufficiently large quantities to warrant automatic testing. Two plugs or sockets which mate with the plugs and sockets at either end of the cableform are wired to pins on an Orion/Atlas type box, which is inserted in the test position in the usual way. When the cableform under test is plugged in to these plugs or sockets, it will constitute a number of links. A programmed tape is made to suit the cableforms, and the ends joined together to form a loop, so as to obviate re-loading the tape after every test. A test run will indicate whether the wiring is correct, and whether any short-circuits are present between wires.

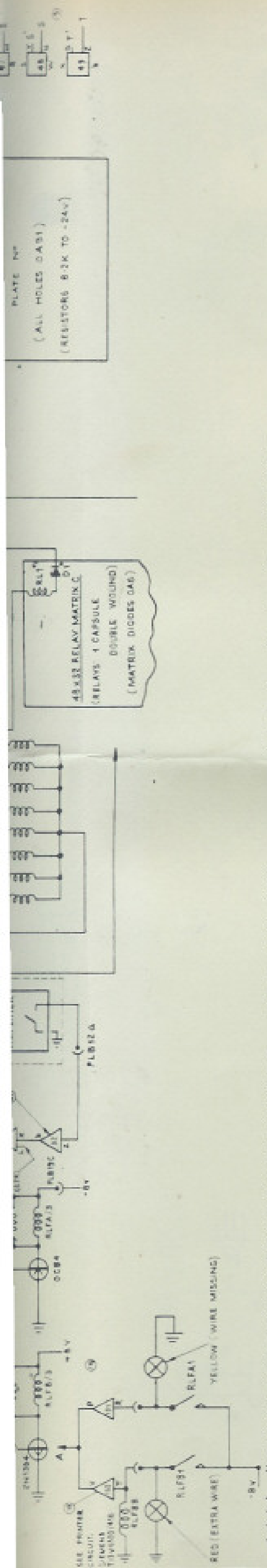
5
Printed Circuit boards from which the relay matrix is built up



GATE INPUTS
PIN LOCATION STORAGE F/FS
PIN X1 NUMBER
PIN X10 NUMBER
PLATE X1 NUMBER
PLATE X10 NUMBER
SINGLE SHOT CIRCUIT
TO CLOCK
START & STOP GCTS FOR 100 Ω RESISTOR MEASUREMENT
TAPE CHARACTER SELECTION CCT
NUMBER GATES
FROM SHIFT GATE 2
(FROM RING COUNTER)
OUT OF STEP CIRCUIT
IF OUT OF STEP STOPS TAPE READER
(FROM SHIFT GATE 2)
NUMBER FEED CIRCUIT
PLATE X 10 STORAGE F/FS
TAPE READER DIGIT F/FS
READER READY
START
DELAY



TO STORAGE F/FS & RELAY SELECTION F/FS
PLATE X 10 NUMBER
PLATE X 1 NUMBER
PIN X 10 NUMBER
PIN X 1 NUMBER
STATICISOR LAMPS
POWER OUTPUT GATES
PIN X 10 STORAGE F/FS
PIN X 1 STORAGE F/FS
PLATE X 1
COMMA
PIN X 10
PIN X 1
USED ON BISTABLE TEST
USED ON EQUIVALENCE TEST
TO F ON RING COUNTER
10 X 4 MATRIX Y
PIN No
(INPUT DIODES OA47
MATRIX DIODES OA91)
(RESISTORS 8.2K TO -24V)
10 X 5 MATRIX X
PLATE No
(ALL DIODES OA91)
(RESISTORS 8.2K TO -24V)
48 X 32 RELAY MATRIX A
(RELAY: 2 CAPSULE SINGLE WOUND)
(MATRIX DIODES OA6)
48 X 32 RELAY MATRIX B
SINGLE WOUND
(MATRIX DIODES OA6)
10 X 5 MATRIX X'
PLATE No
RELAY CONTACT MATRIX
RELAY HOLD WINDINGS
D C AMPLIFIER
CONNECTED TO D1
CONNECTED TO D17



NOTES:-

1 S1 IS SHOWN IN THE EQUIVALENCE TEST POSITION.

2 EXAMPLE OF RELAYS TO BE OPERATED
SUPPOSE PINS 1, 3, 7, 12 ARE CONNECTED ON BOX

CONTINUITY CHECK

RL1 RL1
RL3
RL7
RL12

RESISTANCE CHECK

RL1, RL3, RL7, RL12

3 RELAYS ARE DOUBLE WOUND (HELD FOR PERIOD OF EACH TEST)

4 RINGED NUMBERS INDICATE CARD NUMBERS

5 PLUGS AND SOCKETS:-

POWER SUPPLY	A/12
ARGUS BOX	B/60
50 WAY SWITCH	C/6
* MAINS	D/3
RELAY BOARDS	E/3
TAPE READER	H/18

FLIP FLOPS

1, 2, 3, 4 } TAPE CHARACTER SELECTION CIRCUIT

5) INHIBITS SHIFT TO MATRIX A AFTER 1ST RELAY IN MATRIX A HAS BEEN SELECTED (EQUIV. TEST) (ALSO OPERATES & HOLDS RLH/2)

6) DELAY OF OPERATION OF RLH & HENCE RLS UNTIL END OF TWO RING COUNTER COUNTS (RESISTANCE TEST)

7) CROSS CONNECTED TO ALTERNATELY INHIBIT SHIFT GATES TO A & B MATRICES

8) OPERATES WHEN COMMA CHARACTER ON TAPE IS NOT IN STEP WITH COMMA OF RING COUNTER

9-14) RING COUNTER FLIP FLOPS

17-29) STORAGE FLIP FLOPS

30-55) RELAY SELECTION MATRIX FLIP FLOPS

56-58) SINGLE SHOT CIRCUIT FLIP FLOPS

NOR GATES

1. 11 ENTRY SIGNIFIES ARRIVAL OF NUMBER.
2. 2 " STARTS SHIFT PULSES TO RING COUNTER WHEN PIN LOCATION NUMBERS ARRIVE
3. 2 " USED IN CONJUNCTION WITH FLIP FLOP 6
4. 2 " EXTENDS RING COUNTER WHEN FAULT TO ALLOW NUMBERS TO BE PRINTED.
5. 1 " INVERTS A (A=1 WHEN FAULT)
6. 1 " INVERTS NOR GATE 3 O/P
7. 2 INPUT A INHIBITS SHIFT PULSES TO CROSS CONNECTED F/F7 WHEN FAULT, PREVENTING CHANGEOVER OF INHIBITING SIGNALS TO RELAY SHIFT GATES WHEN PRINTING OUT

8 2 ", 9 3 ", 10 2 ", 11 2 ", 12 1 " } ASSOCIATED WITH F/F8

13 2 ", 14 1 " } ASSOCIATED WITH RLT/4 OPERATING CIRCUIT

15 5 " RING COUNTER NOR GATE
16 1 " " INVERTER
17 1 " INVERTER FROM NOR GATE 4

18 4 ", 19 5 ", 20 6 ", 21 1 ", 22 2 ", 23 2 ", 24 1 ", 25 2 ", 26 2 ", 27 1 ", 28 2 ", 29 2 " } NOR GATES TO RELAY SELECTION MATRIX FLIP FLOPS

30 2 ", 31 1 ", 32 1 " } RESISTANCE FAULT CAUSES RLF TO OPERATE / CAUSES RLF TO RELEASE

33 1 " ALLOWS NUMBER FEED GATES TO OPEN
24-45 5 PRODUCE 1 AT O/PS WHEN CHARACTER AT INPUT IF NUMBER INDICATED
46 5 " PRODUCES 1 AT O/P WHEN F.S CHARACTER AT I/P
47 6 " " 1 " " L.F " AND F/F 1 (STATE 0) AT I/P
48 6 " " 1 " " L.F " F/F 2 "
49 5 " " 1 " " L.F " RLH2 OPERATED I/P

55 2 ENTRY STOPS TAPE READER WHEN FAULT OR OUT OF STEP
57-69 2 " 13 GATES USED TO FEED NUMBERS TO TELEPRINTER
70-72 1 " INVERSE OF NOR GATES 46-48
81-84 4 " FEED FROM GATES 57-69
109-112 1 " INVERTERS OF 123-126 O/PS
115 5 " RING RESET ON SWITCHING ON
118 1 " RING COUNTER RESET

119 2 ", 120 1 ", 121 " " } SINGLE SHOT CIRCUIT

123-126 2 ", 127 1 ", 128 2 } PRINTER FEED INHIBIT GATES

POWER NOR GATES

73-76 1 ENTRY INDICATE INVERSE OF POWER NOR GATES 86-88.
85-88 2 } NUMBER FEED CIRCUIT
89 3 ", 90-93 2 " } TAPE READER O/P
94-98 1 " TAPE READER O/P
114 5, 115-117 2 } SPACE ACCEPTANCE CIRCUIT

POWER OUTPUT GATES

99-108 4 ENTRY FEED TO TELEPRINTER
122 4 " POWER OUTPUT + SIGNAL ON TELEPRINTER (BLACK PRINT OUT)
123 4 " POWER OUTPUT − SIGNAL ON TELEPRINTER (RED PRINT OUT)
124-125 1 ENTRY
126 5 "
127 1 "
128 5 "
129 2 "
130 2 "
131-132 1

SHIFT GATES

1 ASSOCIATED WITH FLIP FLOP 1 HOLDS F/F1 WHEN F/F1 CHANGES STATE
2 MAIN SHIFT PULSE SUPPLY FEEDS F/FS 2,4 AND 8
3 ASSOCIATED WITH F/F3, HOLDS F/F3 WHEN F/F3 CHANGES STATE
4 FEED RING COUNTER
5 ASSOCIATED WITH F/F5, HOLDS F/F5 WHEN F/F5 CHANGES STATE
6 ASSOCIATED WITH F/F6, HOLDS F/F6 WHEN F/F6 CHANGES STATE
7 ASSOCIATED WITH F/F7, ALLOWS F/F7 TO CHANGE OVER AT END OF EACH PIN LOCATION UNLESS INHIBITED BY A
8-20 RELAY SELECTION MATRIX AND STORAGE F/FS
21, 22 } STOP AT FAULT SHIFT GATES
23 PROVIDES START SIGNAL TO TAPE READER UNLESS INHIBITED BY FAULT (A) OR OUT OF STEP
24-25 OUTPUT TO WHOLE CIRCUIT SHIFT PULSES
26 SINGLE SHOT CIRCUIT
27 SHARES LOAD OF SHIFT PULSES TO MATRIX SELECTION SHIFT GATES.

AUTOMATIC BOX WIRING

TEST EQUIPMENT

LOGIC DIAGRAM

DRG. No TD65/20/12D

C. Robinson.
Test Equipment
Design Section.
Ferranti.
W. Gorton.

Automatic Box Wiring

Test Equipment

Type 37. Mk.1. Serial No.1.

Description of Equipment

DESIGNER : C. ROBINSON

AUTOMATIC BOX WIRING TEST EQUIPMENT.

1. INTRODUCTION.

The equipment is used for checking automatically that the box wiring on ORION and ATLAS is correct to schedule.

It is also used for checking that the resistance of each wired link is less than 0.1 ohm.

2. GENERAL DESCRIPTION.

A paper tape containing the wiring instructions relating to the box is fed into a tape reader, the output from which is analysed so that characters referring to the pin numbering are accepted and the remaining characters referring to the box title, waveform names and other irrelevant information are rejected.

The pin number characters select corresponding relays in a matrix so that the wiring of the group of pins being tested is simulated electronically. After the last relay of the group has been selected, a test circuit is closed and the simulated and actual wiring connections are compared

If the actual and simulated groups are equivalent, testing continues to the next group of pins; but if there is an extra or missing wire in the group a fault circuit will be closed. The fault circuit stops the tape reader and the location of the fault is printed out. On completion of the print-out the tape reader restarts and the sequence of events is repeated with the next group.

3. PRINCIPLE OF OPERATION.

(a) Continuity Checking.

This can be illustrated by the following example. The schedule specifies that pins X→Y→Z are connected. Relays corresponding to these pins, namely RLX, RLX", RLY and RLZ are operated as shown in the following diagram: